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Review

Examining Factors That Impact Inpatient Management of Diabetes and the Role of Insulin Pen Devices

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ABSTRACT

Insulin administration in the acute care setting is an integral component of inpatient diabetes management. Although some institutions have moved to insulin pen devices, many acute care settings continue to employ the vial and syringe method of insulin administration. The aim of this study was to evaluate the impact of insulin pen implementation in the acute care setting on patients, healthcare workers and health resource utilization.

A review of published literature, including guidelines, was conducted to identify how insulin pen devices in the acute care setting may impact inpatient diabetes management. Previously published studies have revealed that insulin pen devices have the potential to improve inpatient management through better glycemic control, increased adherence and improved self-management education. Furthermore, insulin pen devices may result in cost savings and improved safety for healthcare workers.

There are benefits to the use of insulin pen devices in acute care and, as such, their implementation should be considered.

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R É S U M É

L'administration d'insuline dans les établissements de soins de courte durée fait partie intégrante de la prise en charge du diabète en milieu hospitalier. Bien que certains établissements aient maintenant adopté les stylos à insuline, plusieurs établissements de soins de courte durée continuent d'utiliser la fiole ou la seringue comme mode d'administration de l'insuline. Le but de cette étude était d'évaluer les conséquences de l'introduction des stylos à insuline dans les établissements de soins de courte durée sur les patients, les travailleurs de la santé et l'utilisation des ressources en santé.

Une revue de la littérature existante, dont les lignes directrices, a été menée pour déterminer de quelle manière les stylos à insuline dans les établissements de soins de courte durée peuvent avoir des répercussions sur la prise en charge du diabète en milieu hospitalier. Les études précédemment publiées ont révélé que les stylos à insuline ont le potentiel d'améliorer la prise en charge en milieu hospitalier par le biais d'une meilleure régulation de la glycémie, d'une observance accrue et d'un meilleur enseignement en matière de prise en charge autonome. De plus, les stylos à insuline peuvent entraîner des réductions de coûts et améliorer la sécurité des travailleurs de la santé.

L'utilisation des stylos à insuline comporte des avantages et, de ce fait, leur introduction devrait être considérée.

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Introduction

The prevalence of diabetes is increasing; a predicted 4.2 million people will be living with diabetes by 2020. The cost of diabetes to the Canadian economy was CAN\$11.7 billion in 2010, and if diabetes follows current trends, this number will reach \$16 billion by 2020 (1).

The Canadian Diabetes Association (CDA) estimates that 80% of the costs result from diabetes complications. These complications arise due to poor glycemic control and include microvascular and macrovascular complications, such as chronic kidney disease, retinopathy, neuropathy, stroke, myocardial infarction and death (2).

Diabetes is a common comorbidity in hospitalized patients (3). Canadian practice guidelines support the need to maintain glycemic control in hospitalized patients (4). A diabetes patient whose glycemic control is inadequate during hospitalization may require modifications of their existing diabetes treatment regimens, which may include insulin initiation or intensification (4).

It is imperative that every measure be taken to maintain glycemic control in hospitalized patients, both during their stays and after they are discharged, so as to minimize the risk for complications. One potential intervention to reach this goal is the use of insulin pen devices in both outpatient and inpatient settings.

The insulin pen device has many attributes and was developed with the intention of improving the delivery of the drug and decreasing the burden on the patient. The value of insulin pen use in the outpatient setting has been well defined (5), but a comprehensive evaluation of the impact of using insulin pens in the Canadian acute care setting is lacking. A conservative estimate of 12% to 26% of hospitalized patients have diabetes, and inpatient management of hyperglycemia is complex (6). Thus, outlining detailed protocols and defining the role of insulin pens in the management of inpatient diabetes is essential.

With the prevalence of diabetes increasing and hospitalization serving as 1 potential point of insulin initiation, it has been suggested that the various methods of insulin administration in the inpatient setting should be examined so as to benefit from this unique opportunity (7).

The goals of inpatient diabetes management have been indicated as follows: achieve individual glycemic control, treat any diabetes-related complications, prevent any drug-related adverse events and new complications and, finally, implement education regarding diabetes self-management (8). In addition to the aforementioned goals, reducing the cost of treating diabetes is essential in the current economic climate. This review is meant to evaluate the potential impact of insulin pen devices on the objectives of inpatient management of diabetes.

Glycemic Control and Preventing Insulin-Related Complications

Accurate dosing of insulin is important in achieving glucose targets

The clinical outcomes that contribute to the pharmacoeconomic burden of inpatients with diabetes include hyperglycemia, hypoglycemia, length of stay and diabetes-related complications, such as cardiovascular disease (8). According to recommendations by the CDA, patients with diabetes should strive to reach glucose targets so as to avoid or delay diabetes complications (9). In order to maintain optimal glycemic control, patients should be receiving the most accurate dosages as inpatients and outpatients. Insulin pens have been found to have consistent and accurate dose delivery across a range of doses and within the limits specified by the International Organization for Standardization (10).

A prospective, randomized study compared the use of insulin pen devices and the vial/syringe method of insulin administration

in the hospital setting. Patients who were assigned to the insulin pen group experienced fewer hyper- and hypoglycemic events daily while using insulin pens (11). Although not statistically significant, the results suggest that pens contribute to glycemic control in hospitalized patients.

Insulin pen devices deliver more accurate doses than vials and syringes

One study evaluated the handling and dosing accuracy of insulin pens vs. vials and syringes involving both insulin therapy-naïve and insulin therapy-experienced healthcare professionals (nurses and pharmacists) (12). Insulin therapy-naïve healthcare professionals found that the insulin pen was both easier to hold and more stable during injection ($p < 0.01$). For both groups of healthcare professionals, the insulin pen mean dose delivered was significantly closer to the intended dose of 10 U than the dose delivered via vial and syringe ($p < 0.001$) (12). It should also be noted that the syringe and vial methods demonstrated higher degrees of variation in doses delivered than the insulin pen, as demonstrated by the differences in standard deviation from the mean (12).

A similar study of the performance of healthcare professionals in the United States, including physicians, diabetes nurses and educational and institutional nurses, reported comparable results. The mean absolute deviations of the insulin doses administered by healthcare professionals were significantly reduced when using insulin pens compared to vials and syringes ($p < 0.0001$) across 4 different doses (5 IU, 25 IU, 43 IU, 78 IU) (13).

Injection technique and use of shorter needle length are recommended to ensure optimal insulin delivery

In addition to achieving tight glycemic control through accurate dosing, the depth of injection should also be considered (Figure 1). It has been suggested that injection technique holds significance comparable to that of dose and insulin type in achieving glycemic control (14). For optimal absorption of insulin, injection into the subcutaneous tissue is recommended (15). The speed of insulin diffusion depends on the depth of injection. If insulin is injected too deeply, the rapid diffusion results in a shorter duration of action, and these intramuscular (IM) injections result in a broader variability of absorption (16).

An evaluation of skin thickness and subcutaneous adipose layer thickness by ultrasound was conducted in adult patients with diabetes and with a range of adiposity and diverse demographic characteristics. The mean skin thickness ranged from 1.87 mm in the thigh to 2.41 mm in the buttocks. The mean subcutaneous adipose layer thickness ranged from 10.35 mm in the thigh to 15.45 mm in the buttocks (14). The authors estimated, based on their findings, the percentage of injections that would result in subcutaneous (SC) vs. skin or IM drug delivery. It was estimated that using 5 mm needles, 98% of 90 degree insertions are SC and the remainder IM; 6 mm and 8 mm needles showed that proportionately more injections are IM (>5% and 15%, respectively); and 12.7 mm needles showed that 45% of injections would be IM. The use of a 4 mm needle was estimated to deliver drug SC 99.5% of the time (14). Insulin syringes are available as short as 6 mm, whereas safety pen needles are available at 5 mm, and nonsafety pen needles are available at 4 mm.

Reducing the risk for adverse events related to insulin administration

Nurses administering insulin are at risk for experiencing a needlestick injury

A retrospective study in the United States evaluated needlestick injuries to nurses in diabetes care and found that 313 of 400 (78.3%)

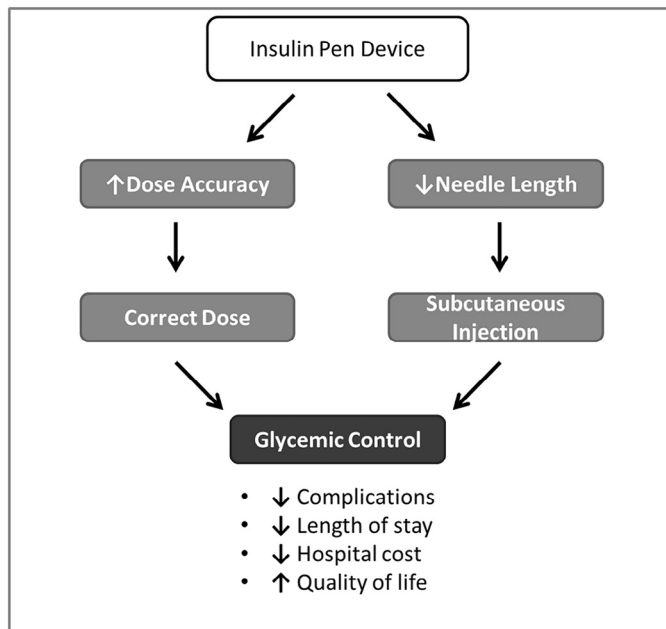


Figure 1. Schematic of the value of the insulin pen device in glycemic control. Individualized glycemic control is crucial for patients with diabetes in order to reduce complications, lengths of stay and hospital costs and to increase quality of life. Insulin pen devices increase dose accuracy, which leads to the correct dose being administered. The shorter needle length reduces the number of intramuscular injections, leading to better absorption of insulin.

nurses had experienced needlestick injuries, with 110 (27.5%) having experienced at least 1 needlestick injury within the past 12 months (17). The needlestick injury that occurred most commonly occurred with insulin injections (30.0%). Notably, a reported 80% of the injuries involved disposable syringes (compared to winged-needle intravenous sets, vacuum tubes and blood-collection needles) (17).

Using an insulin pen can reduce the risk for needlestick injuries and their associated costs

The passive, dual-ended safety technology available for insulin pen needles inherently gives them an advantage over the traditional active safety features for syringes. Thus, it follows that when moving from traditional safety syringes to insulin pen devices with passive safety-engineered needles, a reduction in needlestick injuries would be observed. A retrospective study evaluating needlestick injuries associated with various devices found 2.71 needlestick injuries per 100 000 safety injection devices compared with 0 needlestick injuries per 100 000 insulin pens with safety needles (18).

In a pilot study that evaluated the impact of an interchange program (conventional vial/syringe to disposable, single-ended safety pen device), only 1 staff needlestick injury occurred in the 6 months postimplementation, compared with 5 injuries during the preimplementation period, an 80% reduction (19). A Canadian pilot study evaluating the impact of insulin pens in hospital settings found that 21.2% of nurses preimplementation experienced a needlestick injury (either reported or unreported) compared to 2.6% of nurses postimplementation (20).

A study evaluating insulin pen devices found that pen needles with automatic recapping capabilities resulted in a significant reduction in accidental punctures when administering insulin to another individual ($p < 0.001$) (21). Furthermore, a study evaluating the ability of safety pen devices to protect nurses found that of the 28 needlestick injuries, the majority resulted from nurses recapping needles or assisting patients in recapping their needles (22). Although the safety pen needles are associated with an increase in cost, a

reduction in injuries was observed since implementation of safety pen needles, and this translated to a cost benefit for the pens of a 14% saving (22).

Needlestick injuries are burdensome to the healthcare system and professionals

A needlestick injury can be burdensome to healthcare workers and the institutions in terms of emotional and psychological effects on the individual as well as time lost and cost to the healthcare system. In Canada, the cost of a needlestick injury follow up is approximately \$500, though if the exposure is high risk (i.e. the potential to acquire HIV or hepatitis) this cost could increase by \$1500, for a total of \$2000, including prophylaxis (23). Indirect costs of compensation for time lost were calculated to be approximately \$6000 (23).

In Quebec, the direct costs have been estimated to range from \$272.16 (medium risk) to \$2057.75 for high-risk cases, adding up to \$6030.52 to account for the additional costs related to absence from work (24).

Medication errors related to insulin occur frequently and may compromise patient safety

A prospective study in 14 acute care hospitals in Ontario found that insulin was among the most commonly involved individual drug in medication errors (188 insulin errors in a 12-month period) (25). Furthermore, it was determined that errors occurred most commonly during the administration process (56.6%), and improper dose accounted for 25.7% of the process errors (25). A second study, in the United States, found similar rates of error: 61% of errors occurred during insulin administration, and 26% of errors involved wrong dose, strength or frequency (26).

A study by the Institute for Safe Medication Practices found that insulin is among the top medications commonly involved in errors, with 11% of all errors recorded involving insulin (27). Errors in insulin administration can result in severe adverse events and poor glycemic control in hospitalized patients which, in turn, can result in complications and the costs associated with increased lengths of hospitalization (28). The Canadian Diabetes Cost Model predicts that by 2020, patients with diabetes will spend 5.4 million days in the hospital (9). It is critical that the potential for error be minimized so that the correct dose is given at the correct time, in order for glycemic control to be achieved.

Adherence: Educating Patients with Diabetes for Self-Management

As suggested by Wexler et al, hospitalization presents unique opportunities to impact glycemic control in the long term, when considering a health systems point of view, because hospital admission identifies patients with diabetes at highest risk for uncontrolled diabetes, complications and costs (29). Thus, it is imperative that for insulin-treated inpatients, adequate planning for the transition of care from hospital to home be required to ensure that patients manage changes in treatment regimens (4,30,31).

The CDA and American Diabetes Association practice guidelines suggest that discharge planning should include in-patient diabetes self-management education to teach patients the essential “survival skills” to begin insulin therapy (4,30). If diabetes is not managed adequately postdischarge, patients are at risk for poor outcomes, including rehospitalizations (29).

Adherence is associated with improved glycemic control

Adherence is defined as both compliance and persistence: patients must comply with the correct doses at the prescribed

intervals and must persist for the appropriate durations of time (32). A review of the literature by Asche et al found that most studies (56.5%) found a significant association between improved adherence and better glycemic control (32). In the Canadian context, approximately 5.4% of all hospitalizations are due to medication non-adherence, costing between \$687 million and \$1.6 billion annually (33).

Low adherence rates in patients with diabetes increase the likelihood of diabetes-related complications and healthcare costs

A meta-analysis reporting on adherence to medical treatment determined that diabetes was ranked among the lowest for adherence. This study found the average rate of nonadherence to be 24.8% (34). A systematic review of insulin adherence in patients with type 2 diabetes found an adherence rate of 62% to 64% (nonadherence of 36% to 38%) (35). Other authors have estimated that the rate of non-adherence to diabetes drugs lies at approximately 31.4% (36).

Lack of adherence by patients with diabetes results in a 59% increased likelihood of kidney complications and a 66% likelihood of dying from diabetes-related causes (32). Furthermore, it was found that each 10% increase in adherence to antidiabetic agents results in a mean decrease of hospitalizations by 6.6% and an 8.6% decrease in total annual healthcare costs ($p < 0.05$) (37). Higher medication possession ratios (MPRs) were associated with lower costs, independent of medication type (insulin vs. oral agents) (37).

Kleinman et al found that only 36.5% of insulin users were, at a minimum, 80% compliant, and that medical costs (excluding prescription drug costs) were significantly lower when MPRs were high (38). For example, in the patients who had high costs, patients with 100% MPRs had \$6653 in medical costs compared to \$11 763 for those with MPRs of 10%. Thus, by increasing adherence, there is a potential for significant cost savings (38).

With evidence of this relationship, it would be advantageous to take measures to increase adherence within the patient population.

Insulin pen devices are associated with greater adherence, fewer hypoglycemic events and lower healthcare costs

A study looking at adherence through MPRs found that a significantly higher proportion of patients were adherent (MPRs $> 80\%$) with the implementation of insulin pen devices for patient use ($p < 0.01$) (39). In addition, adherence was associated with reductions in hypoglycemic events ($p < 0.05$), and the all-cause healthcare costs per patient decreased significantly after the implementation of the insulin pen, of which diabetes-related costs comprised approximately 62% of the total healthcare costs. Cost decreases were associated with decreased emergency department visits (7.4 vs. 5.2 visits; $p < 0.01$); hospital lengths of stay (9.6 vs. 6.4 days; $p < 0.01$); and physician visits and pharmacy costs (39).

Insulin pen devices are rated higher in terms of patient preference

In a multicentre, randomized, open-label, 2-period crossover trial comparing patient preference between the vial/syringe method and the insulin pen device, it was found that 74% of patients indicated a preference for the pen, and only 20% preferred the vial/syringe method (40).

The standards set by the National Institute for Health and Care Excellence (NICE), a UK guidance body recognized internationally for adults with diabetes state that patients should have the option of self-monitoring their blood glucose levels and self-administering subcutaneous insulin (41). It was found that patients receiving insulin via the pen device during their hospitalizations were more likely to continue administering insulin at home with this method and to recommend pens to other patients for insulin administration

during hospitalization compared to the vial and syringe ($p < 0.05$) (11).

Insulin pen devices are rated higher in terms of ease of teaching and learning, a critical component in patient education for self-management

Effective education of patients with diabetes while in the hospital is crucial in the process of patient self-management. A study evaluating patient, caregiver and healthcare professional preferences found that using an insulin pen was rated by significantly more subjects as easier to teach (healthcare professionals) and easier to learn (patients and caregivers) (13). Interestingly, significantly more patients in the pen group self-administered insulin during their hospital stays compared to the vial and syringe group (11).

In a study comparing physician, nurse and patient perceptions of the pen vs. the vial/syringe, the pen was preferred significantly over the vial/syringe for teaching ($p < 0.001$) and for learning to use ($p < 0.001$) (42); 100% of nurses and 87% of physicians preferred the pen to the vial/syringe for ease of teaching (42).

In addition to ease of teaching and learning, it has been reported that recommendation of the use of insulin pens (not simply the presentation of pens as an option) by a physician was a powerful differentiator between which patients use and do not use pens (odds ratio, 135.6) (43).

Reducing diabetes-related inefficiencies and cost

With the rising cost of diabetes, it is essential that inefficiencies be identified and targeted to reduce wasteful healthcare spending. The Public Health Agency of Canada (PHAC) reported results from a study in Saskatchewan that compared per capita costs for people with and without diabetes. The results demonstrated that the costs for those with diabetes nearly tripled in the first year after diagnosis. PHAC indicated that this was most likely due to the necessary hospital care at initial diagnosis. After the initial spike, there were minor cost increases, which reflect medication costs, day surgeries and dialysis (44).

In addition to the costs associated with needlestick injuries as they relate to insulin administration, insulin waste and nursing time may also be positively impacted by the use of insulin pen devices.

Reducing insulin waste is important not only to curb healthcare costs, but in an era of drug shortages and a global focus on the environment and sustainability, an effort should be made to reduce insulin waste and the volume of discarded administration supplies. A study involving 5 Ontario hospitals found that an average 34.1% of insulin from vials was wasted (35.6% in the acute care wards) (45). Insulin waste was due largely to expiration (73.9%), with the remaining waste due to patient discharge and spoilage (45). In this 1994 study, the authors recommended that “[hospitals] should estimate their insulin wastage and seek ways to reduce it. The pharmaceutical industry should be encouraged to develop cost-effective insulin delivery systems” (45).

A study in 36 hospitals evaluated how nurses spend their time and found that nurses spend 17.2% of their nursing practice time administering medications (46). The authors concluded that “because nurses devote considerable time to this category of care, opportunities may exist to improve efficiency” (46). Due to the nature of insulin pen devices (i.e. prefilled cartridges and dose dialing), the time for nurses to draw the correct dose and administer to the patient may be reduced.

Converting to insulin pen devices results in overall cost savings to the institution

There have been demonstrated cost savings after conversion to insulin pen devices in hospitals. An interchange program to evaluate

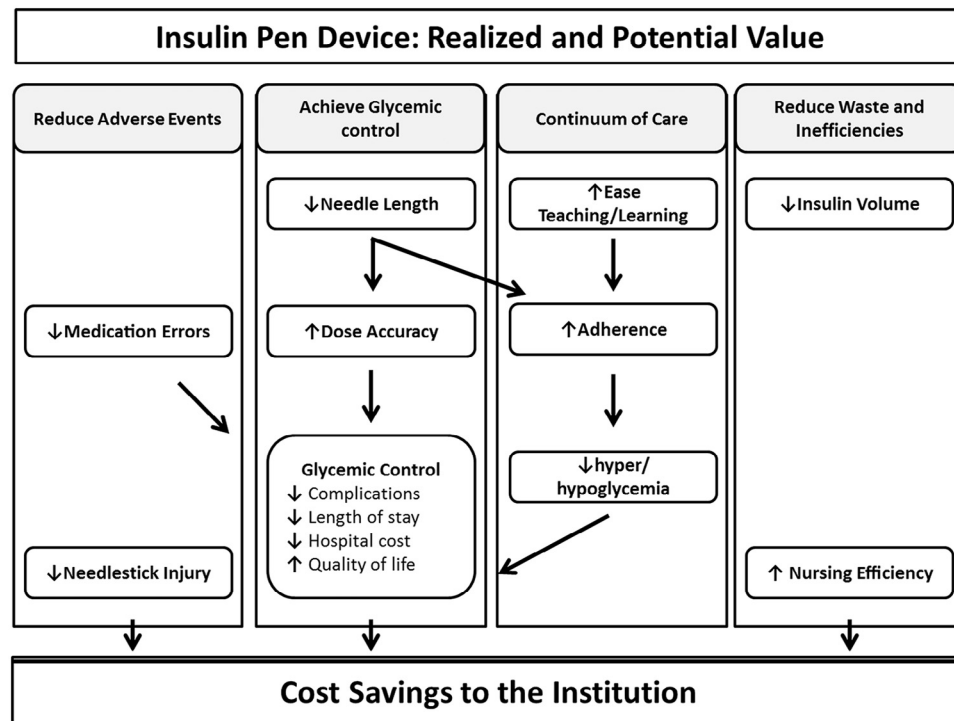


Figure 2. Schematic outlining the realized value and potential value of insulin pen devices in acute care settings.

the impact of pen devices at a 214-bed hospital found that the total cost of insulin products before implementation was \$124 181, compared to \$60 655 after implementation (19). Another study evaluating the financial consequences of insulin pen devices compared to the vial/syringe found a projected cost saving of \$36 per patient if insulin pens were dispensed during the entire hospital stay (11).

Summary

Insulin pen devices are currently used in the outpatient setting and, at times, in the acute care setting. A multitude of published studies and unpublished pilot studies have demonstrated the value of implementing pen devices and a safety pen needle in hospitals. The benefits include reducing the risk for adverse events, such as needlestick injuries and medication errors, and achieving tighter glycemic control as a result of shorter needle length availability (reduction in intramuscular injections and improved adherence). Insulin pen devices in the acute care setting may also decrease waste and inefficiencies, such as insulin waste and nursing time, though further research in these areas is warranted (Figure 2).

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